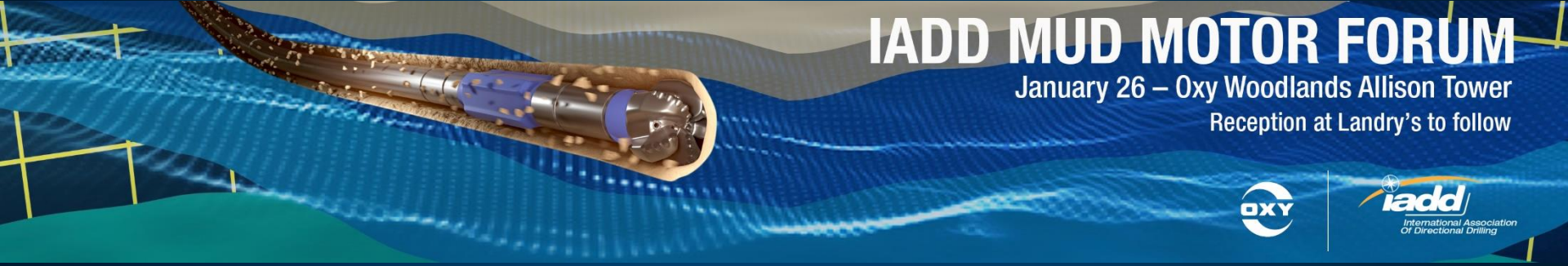


# Welcome



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# Speaker Information

- Carlos Menendez
- Motor Stalling Within Operational Parameters - Causes, Protocols, Repercussions, Prevention, and Redesigning the Limit of Performance
- January 26th, 2023
- Percussion Petroleum
- Texas A&M, Petroleum Engineering, Class of 2016.

# Company / Affiliation Information

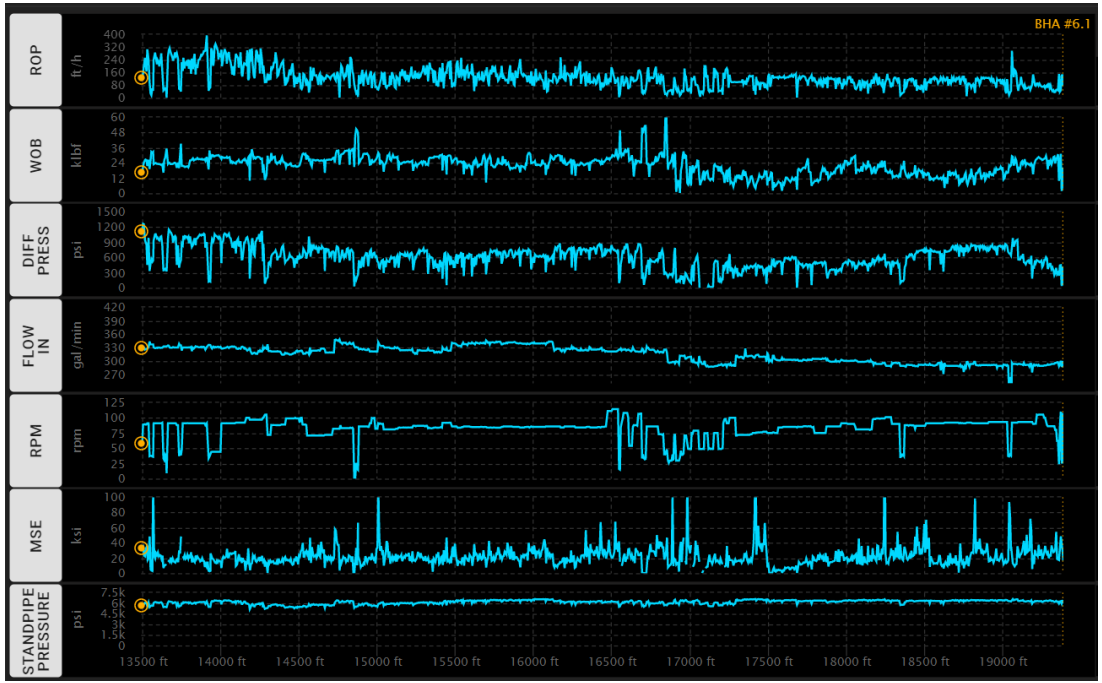
- Percussion Petroleum along with Halliburton DBS.
- Private Equity backed operator in the Eastern Delaware Basin.
  - Winkler and Ward Counties.
  - Data provided thanks to Cerebro Force™, a Halliburton DBS in-bit sensor.

# The Problem

- Repeated stalling within tool constraints that hinders performance. (50-75% of rating).
- Causes – AD setpoints, improper zero, formation, failure to adhere to procedures.
- Mitigation – dyno testing (surface conditions), stall procedures.
- Prevention – redesigning of BHA, improved drilling practices.

# Subject Well – Ward County, TX

- High initial ROP
  - 1,400’ in 12 hrs conventional 6.75” lateral (115 fph), 250-300 fph instantaneous
  - Slowed down to 100 fph by end of run.
- Riding SPP, limiting motor HP
  - 1,200/2,500 max dP (50%)
  - With 325 gpm, 70% of dyno HP and 25% of spec.



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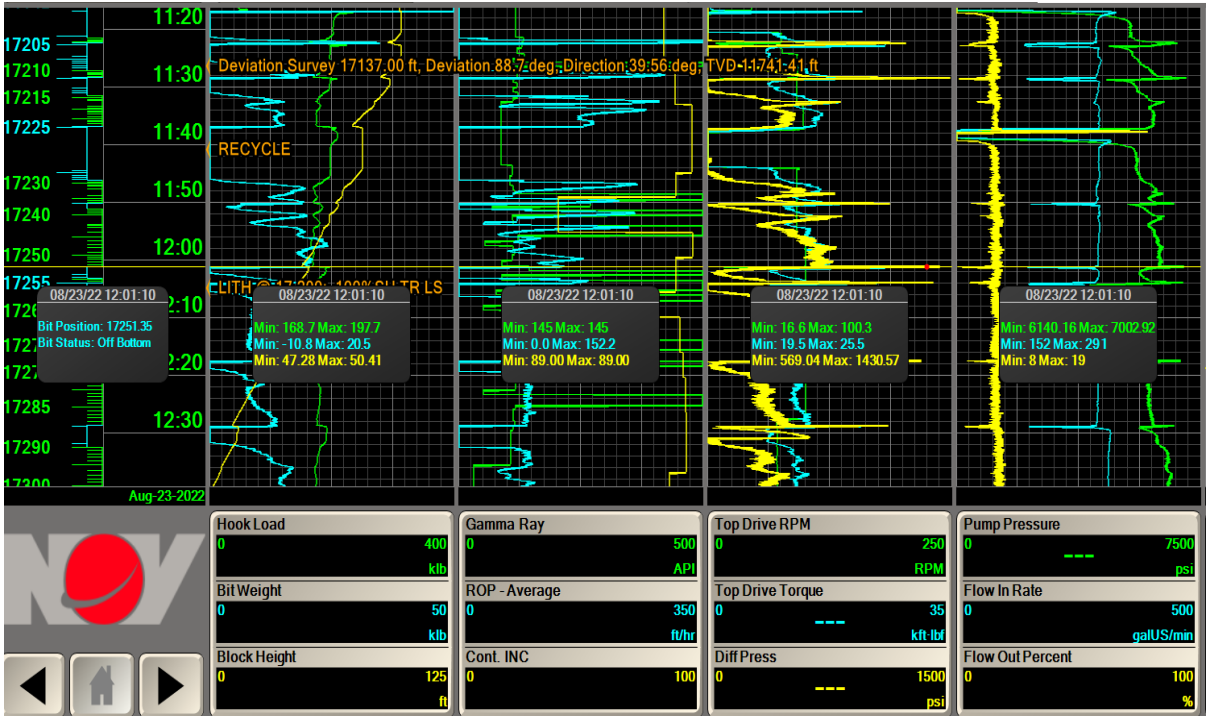
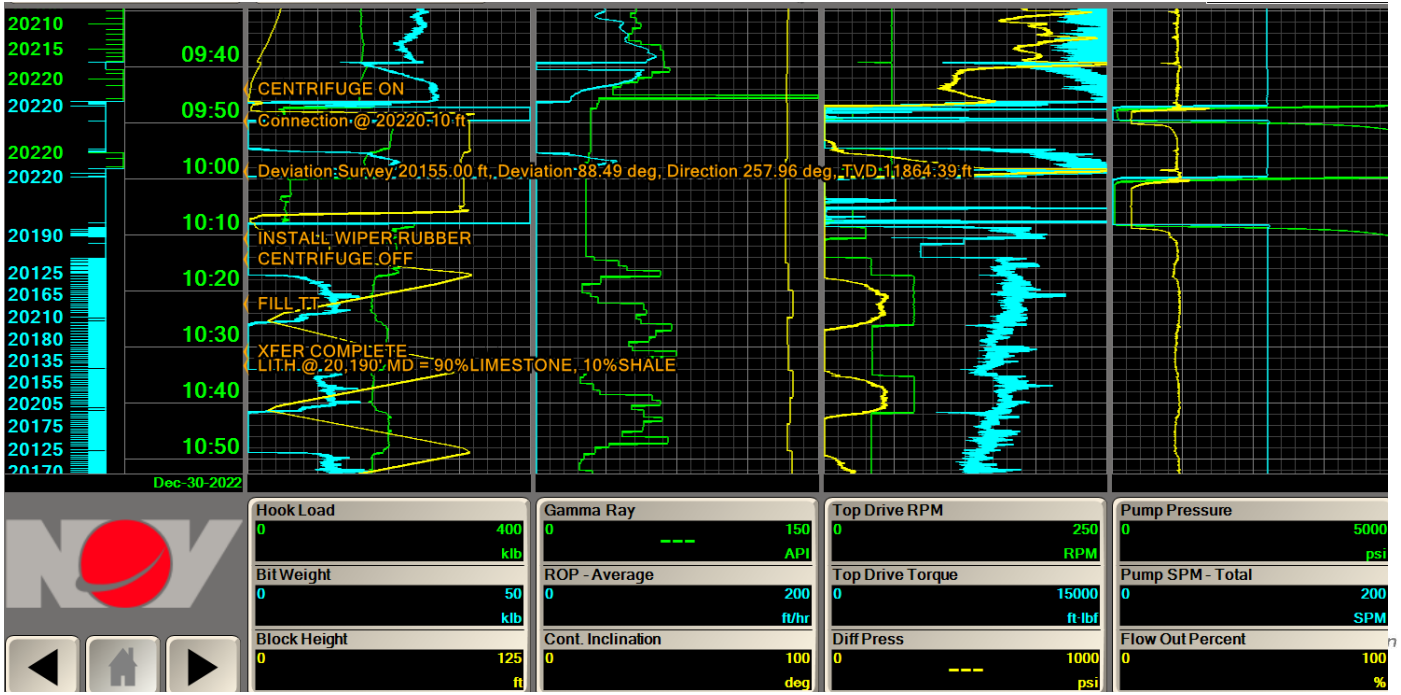
# What does it look like?

- Repeated stalls, unable to “push” as hard as we would like. Forced to reduce WOB.



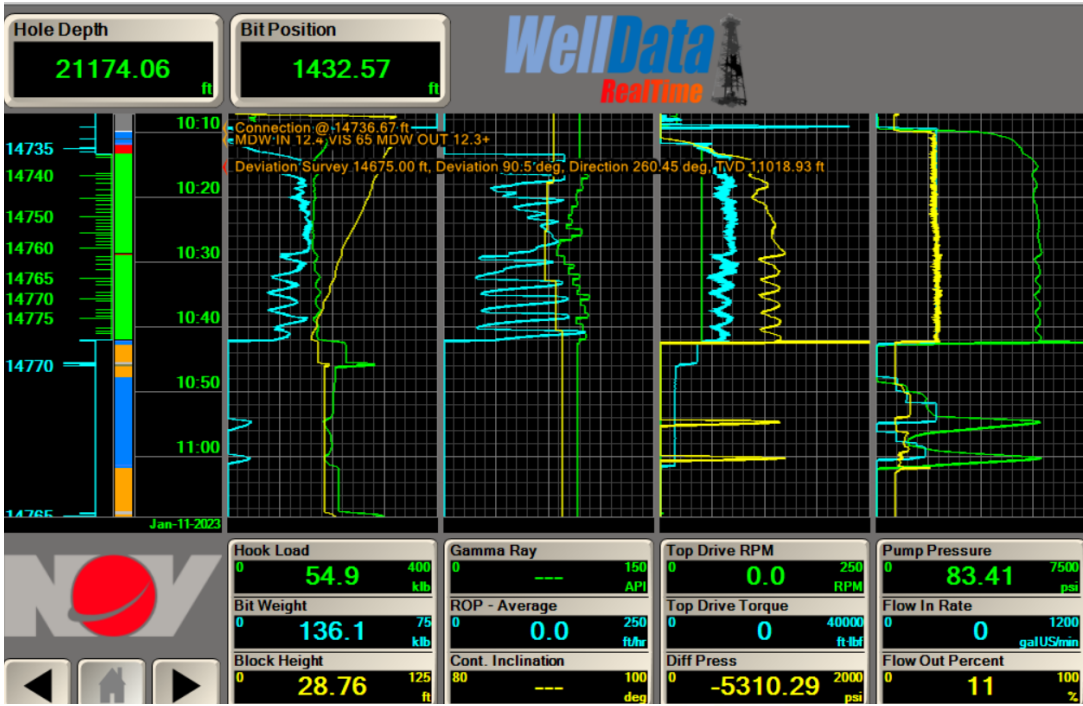
# Causes - Formation

- Interbedded shale and lime as shown in gamma and sample.



# Causes - Improper AD Setpoints

- Right before stall, improper AD settings causing “seesaw” pattern.



# Real Time Response

- Kill mud pump(s)
- Kill rotary and let torque out.
- Pick all the way up until hookload breaks over.
- Kick in rotary and pump and check off bottom psi and torque.

*What can happen if this is not followed?*

i.e.

*Why should the field care & how do we validate the importance of this?*

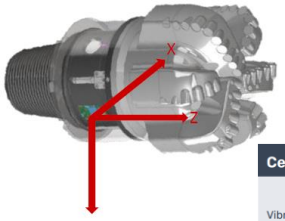
# Cerebro Force Run – In Bit Sensor

## Cerebro Overview

- **Peak X**: Radial + lateral vibrations
  - Side to side motion of the bit measured in "g"
  - Can be caused by transition drilling, whirl, insufficient depth of cut, and/or other downhole dysfunction(s)
  - VibeX also picks up centripetal acceleration due to rotation, averaged out in 1-second data but visible in 1000 Hz data.
- **Peak Y:** Torsional + lateral vibrations.
  - Difference in VibeY and VibeX is related to torsional accelerations caused by high frequency events like HFTO and bit whirl.
  - Does not pick up low frequency stick-slip, unless whirl occurs in slip phase.
- **Peak Z**: Axial vibration
  - Motion of the bit in the drilling axis ("bit bounce") measured in "g".
  - Typically seen during transition drilling, anhydrites, chert / pyrite.
- **Avg_Roll**: Gyro RPM averaged over 1 second.
  - A wide band of data suggests RPM is swinging up and down over many seconds.
  - A tight band indicates either smooth rotation or rotation with variation at higher than 1 Hz.
- **SSI_Roll:** Stick-slip indicator, a measure of how severe the low frequency RPM variation over a 30 second window is.

$$SSI\ Roll = 100\left(\frac{Maximum\ RPM - Minimum\ RPM}{Average\ RPM}\right)$$

- **Avg_WOB, Avg_TOB**: At bit WOB and Torque on Bit, respectively.
- **AbsAvgBOB:** Bending on bit, directly related to side force at the bit




| Cerebro Force™ Sensor Specifications | | |
|---|---|---|
| Vibration | Axes | 3 |
| | Range | +/- 8 g |
| | Accuracy | +/- 40 mg |
| Shock | Axes | 3 |
| | Range | +/- 200 g |
| | Accuracy | +/- 500 mg |
| Magnetometer | Axes | 3 |
| | Range | +/- 16 gauss |
| Accel/Mag RPM | Axes | 3 |
| | Range | 0 to 1,200 rpm |
| | Accuracy | +/- 7 rpm |
| Gyro RPM | Axes | 3 |
| | Range | +/- 666 rpm |
| | Accuracy | +/- 0.5 rpm |
| Strain | Axes | Weight-Torque-Bending |
| | Range | Connection Limited |
| Specifications | Run Time | 75-350 hr* |
| | Max. Sample Rate | 1,024 Hz |
| | Max. Temp | 266°F (130°C) |
| | Max. Pressure | 25 kpsi |
| | ID Restriction | None |





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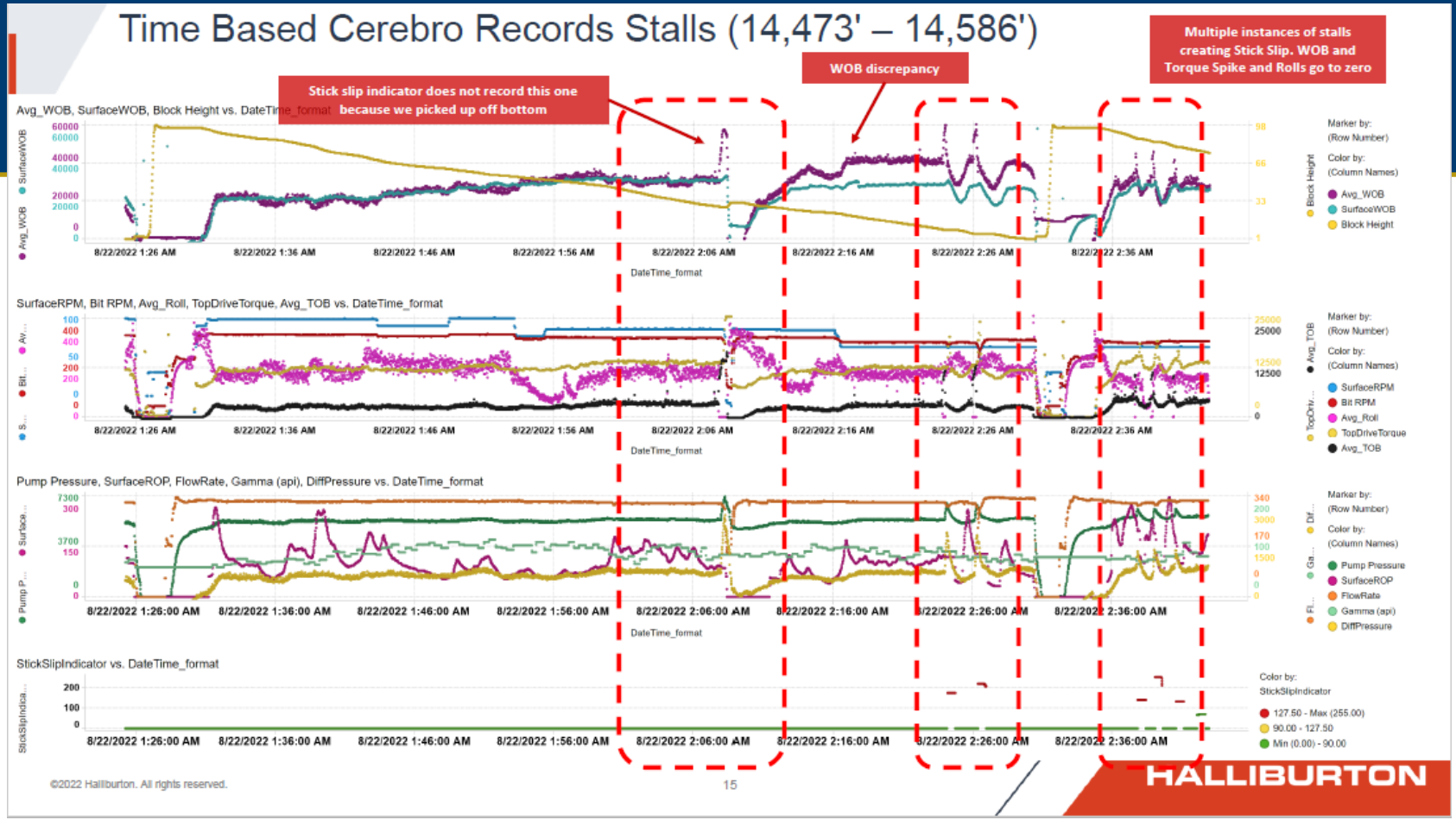
# Time Based Cerebro Records Stalls (14,473' – 14,586')





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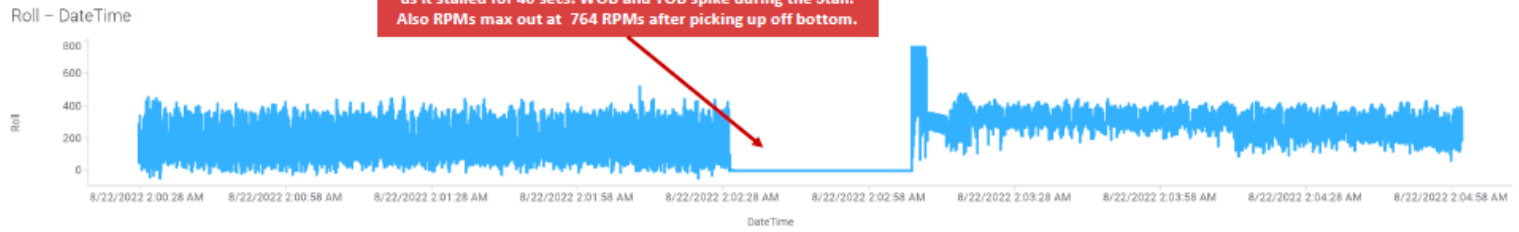
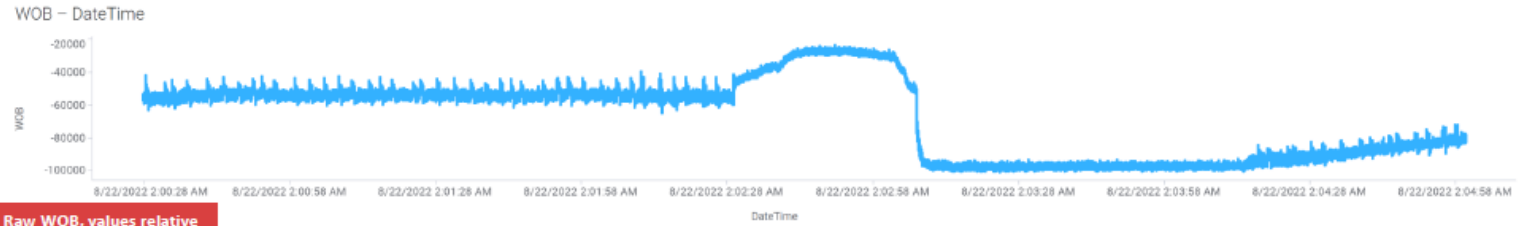
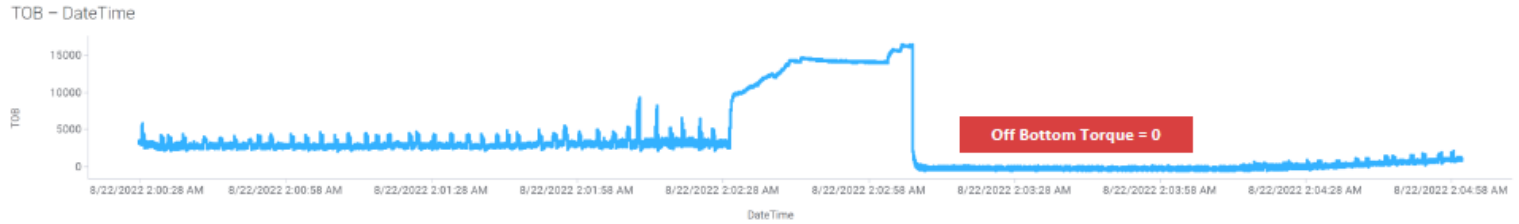
# High Frequency Analysis of first stall @ 14,539'

Eventhough Cerebro did not record as Stick Slip HF data tells us it stalled for 40 secs. WOB and TOB spike during the Stall. Also RPMs max out at 764 RPMs after picking up off bottom.




Raw WOB, values relative




Off Bottom Torque = 0

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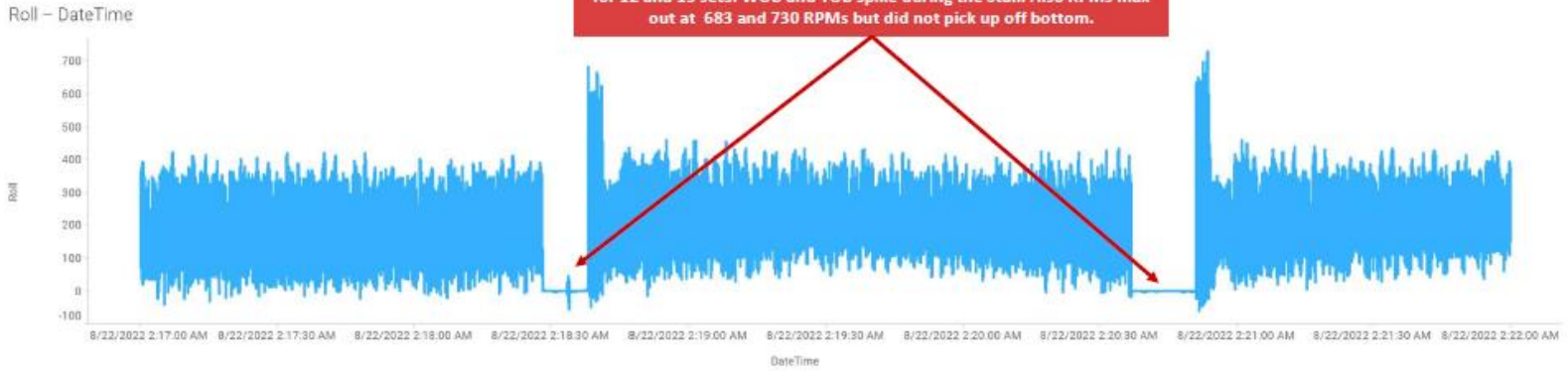
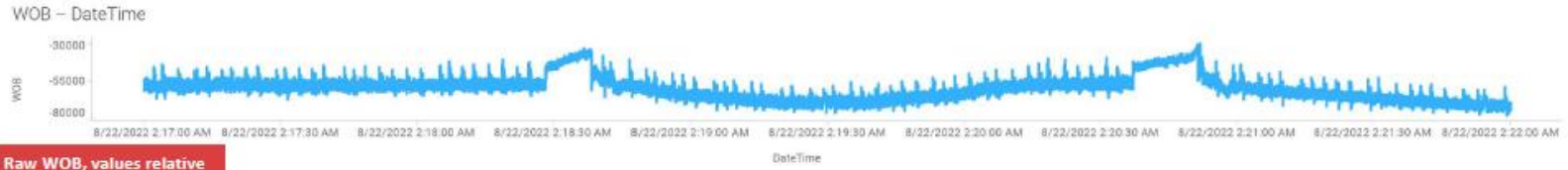
# High Frequency Analysis of next two stalls @ 14,559' & 14,563'

In this case Cerebro did record as Stick Slip and HF data tells us it stalled for 12 and 15 secs. WOB and TOB spike during the Stall. Also RPMs max out at 683 and 730 RPMs but did not pick up off bottom.

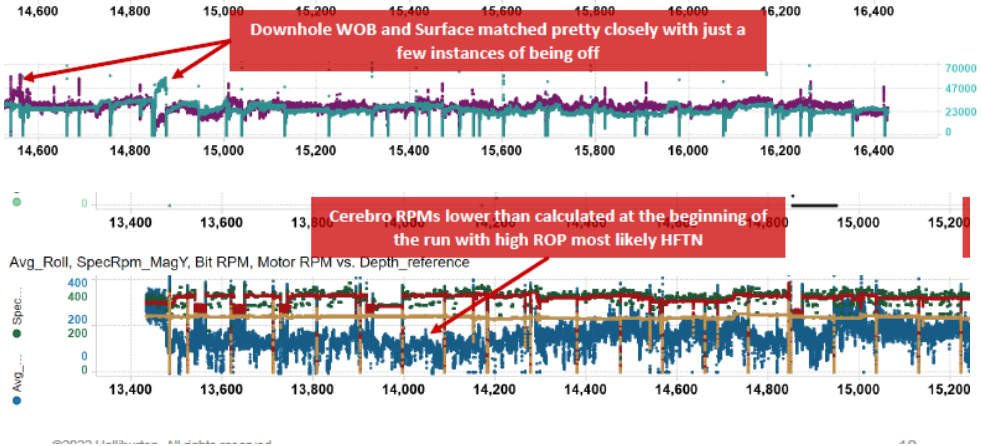



Raw WOB, values relative

# Other Notable Findings and Possible Causes

- High levels of HFTO noted.
  - Although typically thought of as separate issue, could cause premature wear and/or stalls.
  - Other data captured shows delta rpm during HFTO are lower with slower speed motors. (RSS)
- Accurate WOB calibration during run.
  - Typically run less WOB in extended reach, but this sensor can also show when we do not pick all the way up off bottom during connections we may still have trapped weight and/or torque, leading to damage.



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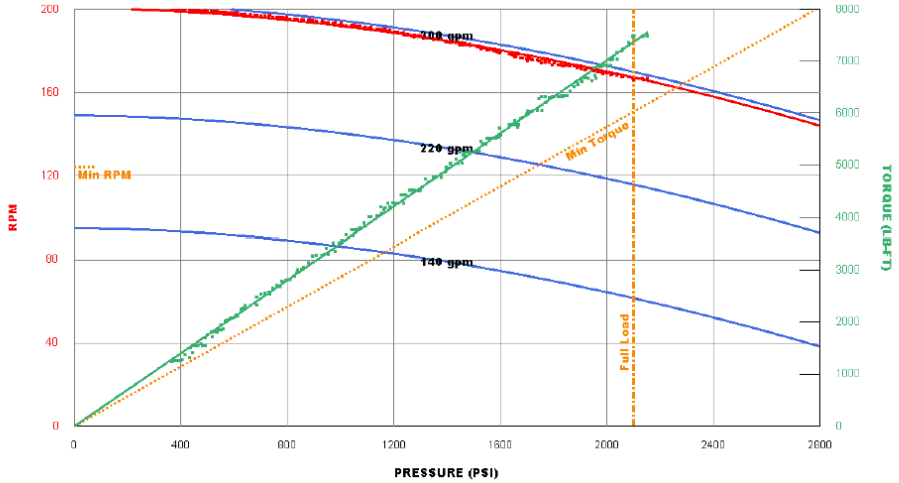
# Mitigation – Dyno Testing

- Weeds out the “bad apples”.
- Done with surface conditions and pressure.
- Can this process be further optimized to downhole conditions with investment?



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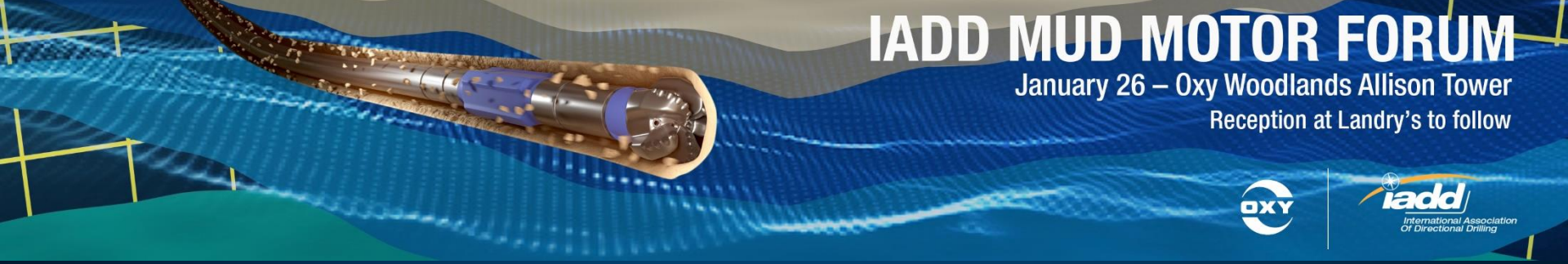
# Engineering Redesign

- Bit Design and selection.
  - Optimized DOCC and diamond volume placement.
- Rotor stator fit – basin & area.
- Different power section, speed, Torque output.
  - Bigger is not always better.
- Higher SPP system.
- On-demand/zero pressure drop tools.

Increased downhole horsepower.

# Conclusion

- Motor stalling that impedes performance is a problem seen with several stator manufacturers caused by:
  - Improper AD settings/parameters.
  - Formation & transitions.
  - Too aggressive design &/or improper fit.
- The problem is aggravated by:
  - Not following proper stall procedures. Cannot see the dysfunction from surface.
  - Not dyno testing motors in advance.
- To prevent this issue (currently):
  - Optimize bit and motor design/selection, rotor stator fit.
  - Increase system hydraulic horsepower capabilities. (rig, BHA, TFA, drillstring)
  - Key in on parameters, AD settings, stall procedures being followed.
  - Perform Dyno Testing.
- Going Forward:
  - Dyno Testing with downhole conditions?
  - Zero Pressure Drop Tools
  - Increased rig capabilities. (10k psi)


IADD MUD MOTOR FORUM
January 26 – Oxy Woodlands Allison Tower
Reception at Landry's to follow
OXY
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# Thank You